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USDA FOREST SERVICE RESEARCH NOTE INT-189

CHARACTERISTICS OF DOUGLAS-FIR BEETLE INFESTATION IN NORTHERN IDAHO RESULTING FROM TREATMENT WITH DOUGLURE

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ABSTRACT

Nearly 800 mature Douglas-fir trees along logging roads were baited with Douglure at approximately 4-chain intervals. After beetle attack, trees were examined for infestation within 2 chains of 24 baited trees. Nine untreated "spillover" trees were attacked for each treated tree. Beetles failed to produce brood in 56 percent of the attacked trees. Successfully attacked (susceptible) trees were significantly larger and were infested to a significantly greater density and length than were unsuccessfully attacked (resistant) trees. Baited trees were more susceptible to successful attack than were spillover trees. Brood/parent ratios were less than 0.5 in successfully attacked trees in early August. The study indicates that tree size and stand density affect the rate and success of Douglas-fir beetle attack in the vicinity of Douglure treatment.

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KEYWORDS: Insects, attractants, Douglas-fir beetle, bark beetle, Douglure, aggregating pheromone, forest protection

The Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins, causes economic damage to Douglas-fir sawtimber in many areas of the West. A recent infestation in the Clearwater River drainage of northern Idaho killed 109 MMbf of timber from 1970 through 1972 (Ciesla and others 1971; McGregor and others 1972; McGregor and others 1974).

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As part of a coordinated salvage program in cooperation with the Northern Rockies Forest Pest Action Council, the Douglas-fir beetle attractant, Douglure,[2] was tested in the North Fork Clearwater River drainage in northern Idaho by Potlatch Corporation for its utility in concentrating beetles in accessible trees to be removed by logging. Treatment with Douglure--a mixture of frontalin, α-pinene, and camphene--has been shown to result in beetles attacking both baited and nearby "spillover" trees (Knopf and Pitman 1972; Pitman 1973). These studies have resulted in proposals of a strategy of concentrating or "trapping out" beetle populations with aggregating pheromone chemicals such as Douglure.

Baiting was more intense in the Buck and Doe Creek drainages than in any other reported project. We decided to take advantage of this high baiting level to document the proportions of successfully and unsuccessfully attacked trees. Such information would aid planning of a test of a "confusion" strategy involving areawide application of aggregating pheromones such as Douglure to disrupt normal aggregation on host trees. A particular concentration and spacing of the pheromone might subject each Douglas-fir in the treated forest to equal risk of attack, thus dispersing the beetle population to the extent that most trees would survive the resulting low density of attack. Previous study has shown that unsuccessfully attacked trees contained 3.4 galleries per ft^2 compared to 10.9 per ft^2 in successfully attacked trees.[3]

METHODS

From May 5 through 10, 1973, nearly 800 live Douglas-fir near logging roads were treated at approximately 4-chain intervals with Douglure in Buck and Doe Creek drainages (fig. 1), 16 miles northeast of Orofino, Idaho. The largest trees were baited. The treatments were as per Pitman (1973), except that two instead of four Douglure-charged polyethylene containers were attached to each baited tree at breast height. The removable caps on some containers dissolved, so it is possible that the rate of diffusion of Douglure may have exceeded that in earlier reported experiments.

From July 30 through August 3, 1973, we randomly selected 24 sample plots within the resulting infestation. We measured diameter at breast height and estimated the infested height, based on frass and exuded resin, for the treated tree at the center of each plot. Identical data were obtained for spillover trees within the following distances from treated trees: 0 to one-half, one-half to 1, and 1 to 2 chains. Attack success was also determined for all standing trees on all plots by chopping into the bark 8 to 12 ft above ground and examining egg galleries in the phloem. Based on degree of resinosis, abundance of brood, and condition of the phloem, trees were rated (1) successfully attacked (susceptible), (2) intermediate, or (3) unsuccessfully attacked (resistant). We also determined the basal area of each plot with a 25 basal area factor prism (Dilworth and Bell 1973).

On 13 of the plots we felled the baited tree and a randomly selected spillover tree in each of the three distance classes if one occurred there. Then we measured the exact infested height and located three 1-ft^2 sample areas at one-fourth, one-half, and

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[2]Use of trade or firm names is for reader information only, and does not constitute endorsement by the U.S. Department of Agriculture of any commercial product or service.

[3]M. M. Furniss. Observations on resistance and susceptibility to Douglas-fir beetles. Paper presented at Second North American Forest Biology Workshop, Oreg. State Univ., July 31-Aug. 3, 1972.

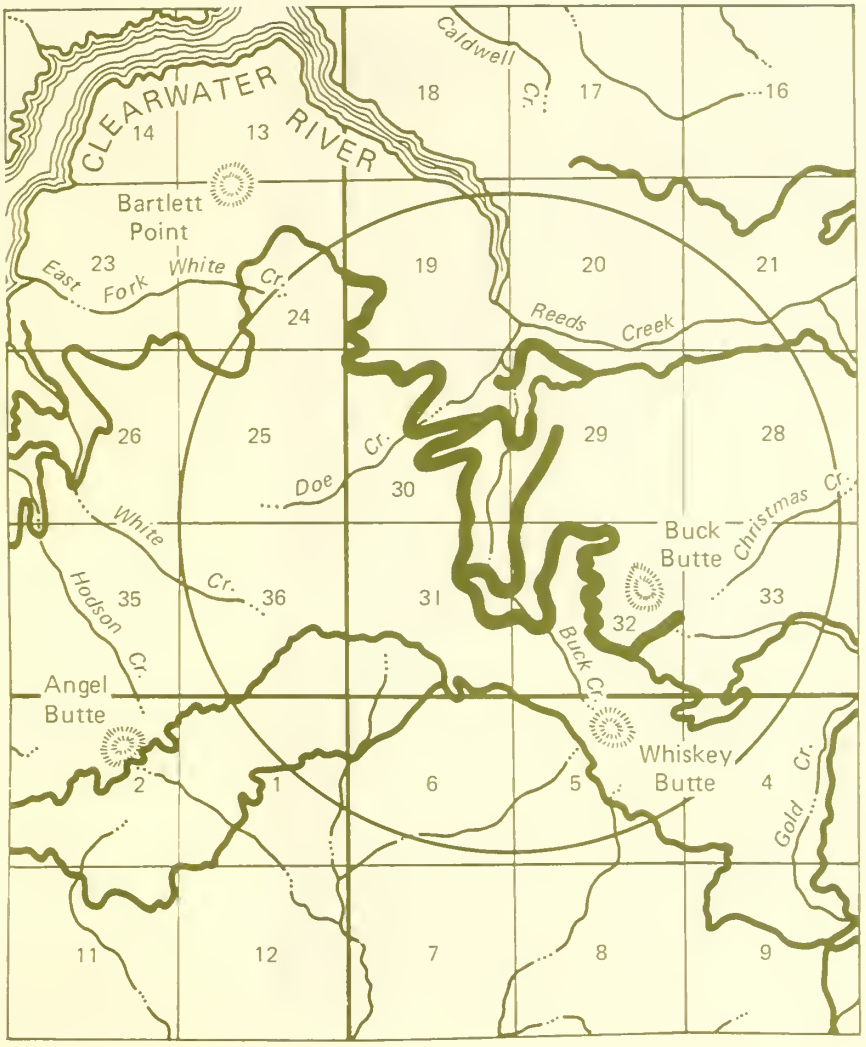

Figure 1.--Roads along which trees were baited with Douglure.

three-fourths the distance from the stump to the uppermost attack area. From these samples we determined the number of attacks, length of egg galleries, and numbers of parent beetles present (fig. 2). On a 6- by 6-inch subsample we counted the number of live brood by stage. The smaller sample was used because brood density was often greater than the variables measured on the larger sample.

The significance of differences of sample averages was determined from treated and spillover trees by distance class. Infestation characteristics (infested height, brood density, and gallery length) were regressed stepwise on tree characteristics and distance from baited tree to determine significant sources of variation and their relative contribution toward variation in the dependent variable.

Figure 2.--Determination of number of Douglas-fir beetle galleries on bark sample from unsuccessfully attacked "spillover" tree.

RESULTS AND DISCUSSION

The effectiveness of Douglure as an attractant was again demonstrated. Treatment of roadside trees at ca. 4-chain intervals generated an estimated 8,000 attacked trees, 89 percent of which were spillovers. Fifty-six percent of the trees were attacked unsuccessfully but this rate did not appear to be greater than was observed elsewhere in the untreated areas.

Tree Characteristics by Success of Attack and Distance From Treatment

We found that our initial classification of "Intermediate" susceptibility of standing trees was not always consistent with brood success on bark samples after trees were felled. Where broods were found, we combined "Intermediate" with the "Susceptible" class.

Generally, the susceptible trees were significantly larger, and were infested to a significantly greater height than were the resistant trees (table 1). Differences tended to be less as distance from the baited tree increased, but these differences were not significant except in the case of infested height in susceptible trees.

Table 1.--*Average tree measurements by success of attack and distance from Douglure treated trees on 13 plots*

Distance class	Trees measured	D.b.h.	Age	Tree height	Infested height
		Inches	*Years*	*Feet*	*Feet*
		RESISTANT TREES			
Plot center (Baited tree)	7	[1] 17.4a	121a	110a	30a
<1/2 chain	4	17.3a	142a	108a	24a
1/2-1 chain	8	16.5a	125a	116a	32a
>1 chain	4	16.0a	119a	107a	28a
		SUSCEPTIBLE TREES			
Plot center (Baited tree)	6	23.3b	147a	118a	66b
<1/2 chain	5	20.7b	137a	114a	45c
1/2-1 chain	6	21.2b	142a	114a	59d
>1 chain	5	20.4b	118a	106a	48e

[1]Means with a common alphabetical suffix do not differ significantly; those having different suffixes differ significantly at the 0.05 level of probability.

Density of Attacks and Brood by Distance From Treatment

Baited and susceptible trees were attacked significantly more densely than were spillover and resistant trees (table 2). Baited trees were successfully attacked at a significantly higher rate than were spillover trees (table 3). All but two of the baited trees were attacked. One was in a cutover area with no other Douglas-fir within 2 chains, the other was in a stand containing only one other Douglas-fir within 2 chains.

We interpret the difference in density and success of attack to the effectiveness of Douglure which evidently aggregated more beetles on the baited trees, and to baited trees being generally greater size (table 1). A previous study (footnote 3) showed that successfully attacked trees were significantly larger than unsuccessfully attacked trees in naturally attacked tree groups.

The brood/parent ratios in successfully attacked trees were low (table 2) at the time of sampling (July 30-August 3). However, a relatively low (0.8) ratio was also found in an independent survey of naturally attacked trees elsewhere in the Clearwater drainage in September (McGregor and others 1974). These low ratios may be due to the very dry, warm summer; other natural factors involved in the declining phase of the outbreak; or, in the case of Buck and Doe Creeks, to use of Douglure on trees not selected naturally by beetles. Whatever the case, brood ratios less than 1.0 indicate a declining population unless compensated for by reemergence of parents and establishment of a second brood.

Table 2.--*Density of Douglas-fir beetle attacks, parents, and brood/parent ratios by distance from treatment on 13 Douglure plots*

Distance class	Number of observations	Attacks	Live brood	Parents on sample	Brood/ parent ratio[1]
			Number per ft²		
		RESISTANT TREES			
Plot center (Baited tree)	7	9.2	0	0.17	0
<1/2 chain	4	5.1	0	.19	0
1/2-1 chain	8	5.3	0	.03	0
>1/2 chain	4	3.0	0	0	0
		SUSCEPTIBLE TREES			
Plot center (Baited tree)	6	11.9	5.9	0.30	0.25
<1/2 chain	5	7.5	2.9	.56	.19
1/2-1 chain	6	8.5	8.1	.37	.48
>1/2 chain	5	8.7	4.9	.29	.28

[1]Number live brood ÷ 2(number of attacks).

Table 3.--*Success of attacks by distance from baited trees on 24 Douglure-treated plots*

Distance class	Attack category		
	Successful	Intermediate	Unsuccessful
	Percent of total		
Plot center (baited tree)	67	25	8
<1/2 chain	45	6	49
1/2-1 chain	34	5	61
>1 chain	45	5	51

Significant Sources of Variation in Baited and Spillover Trees

Table 4 lists significant sources of variation between bark sample data and tree characteristics in baited and spillover trees.

Table 4.--*Results of multiple regression of attack characteristics and tree characteristics for 24 Douglure-treated plots*

Factor	Variable	Significance[1]	
		Baited	Spillover
Infested height	D.b.h.	N.S.	0.001
	Brood density	0.001	.001
	Gallery length	N.S.	N.S.
	Distance	N.S.	N.S.
	Diameter growth (D.b.h./age)	N.S.	N.S.
	Height growth (Height/age)	N.S.	N.S.
	Form (D.b.h./height)	N.S.	N.S.
	Age	N.S.	N.S.
Live brood per square foot	Form	N.S.	.001
	Gallery length	N.S.	.1
	D.b.h.	.005	.1
	Height	N.S.	N.S.
	Distance	N.S.	N.S.
	Age	N.S.	N.S.
	Diameter growth	N.S.	N.S.
	Height growth	N.S.	N.S.
Total gallery length per square foot	Attack density	N.S.	.001
	Form	.001	.001
	Brood density	N.S.	.025
	Diameter growth	N.S.	N.S.
	Height growth	N.S.	N.S.
	Distance	N.S.	N.S.
	Age	N.S.	N.S.
	Height	.01	N.S.

[1]N.S. = no statistical significance.

In the baited trees the height of infestation was not significantly related to tree diameter nor was the density of the galleries significantly related to length of galleries intercepted by samples. Also, in the baited trees, the average length of the galleries per square foot had no significant relation to density of live brood, but the taller trees produced more inches of galleries per square foot.

In spillover trees, the height of the infestation was directly related to tree diameter, and density of attacks was directly related to gallery length and brood density. However, there was no significant relationship to gallery length and tree height in spillover trees.

Diameter growth, height growth, tree age, and distance from the baited tree showed no significant relationship to infested height, brood production, or gallery length in either baited or spillover trees.

Stand Composition and Basal Area in Relation to Infestation

Results of our sampling of stand composition and basal area on 24 plots are shown in table 5. Statistical analysis of basal area and (1) proportion of trees that were attacked, (2) percent of successful attacks, and (3) brood density disclosed no significant relationships. Perhaps lack of significance may have been due to an omission of smaller diameter trees with the 25-factor prism method, but we can only speculate on that.

Table 5.--*Basal area and proportion of tree species on 24 randomly selected Douglure treated plots*

Species	Basal area/acre	Percentage
	Ft^2	
Douglas-fir	83.3	38
Cedar	63.5	29
Grand fir	36.4	17
Larch	21.9	10
Ponderosa pine	9.4	4
White pine	4.2	2
Total	218.7	100

CONCLUSIONS AND RECOMMENDATIONS

We noted that the number of attacked trees surrounding a baited tree increased in proportion to the surrounding area out to 1 chain (fig. 3), decreasing thereafter. This relationship provides limited insight into the spacing relationship of Douglure and resulting attack in the surrounding stand. Evidently, at the existing population level and Douglure concentration employed, spacing would have to be less than 4 chains if all intervening Douglas-fir were to be subjected to attack.

The original objectives and design of the baiting project did not provide for evaluating the overall effect of baiting on the beetle population and damage. Nonetheless, the attacked trees were attacked by far more beetles than the attackers produced, as shown by exceptionally low brood/parent ratios.

In commercial forests, application of aggregating pheromones such as Douglure may be combined with logging of infested trees. However, the method needs further testing and development to demonstrate its efficacy in suppressing beetle damage. Meanwhile, if inducing a high rate of successful attack is the objective of a Douglure treatment, our study confirms that larger trees in rather dense stands of Douglas-fir are more susceptible to attack.

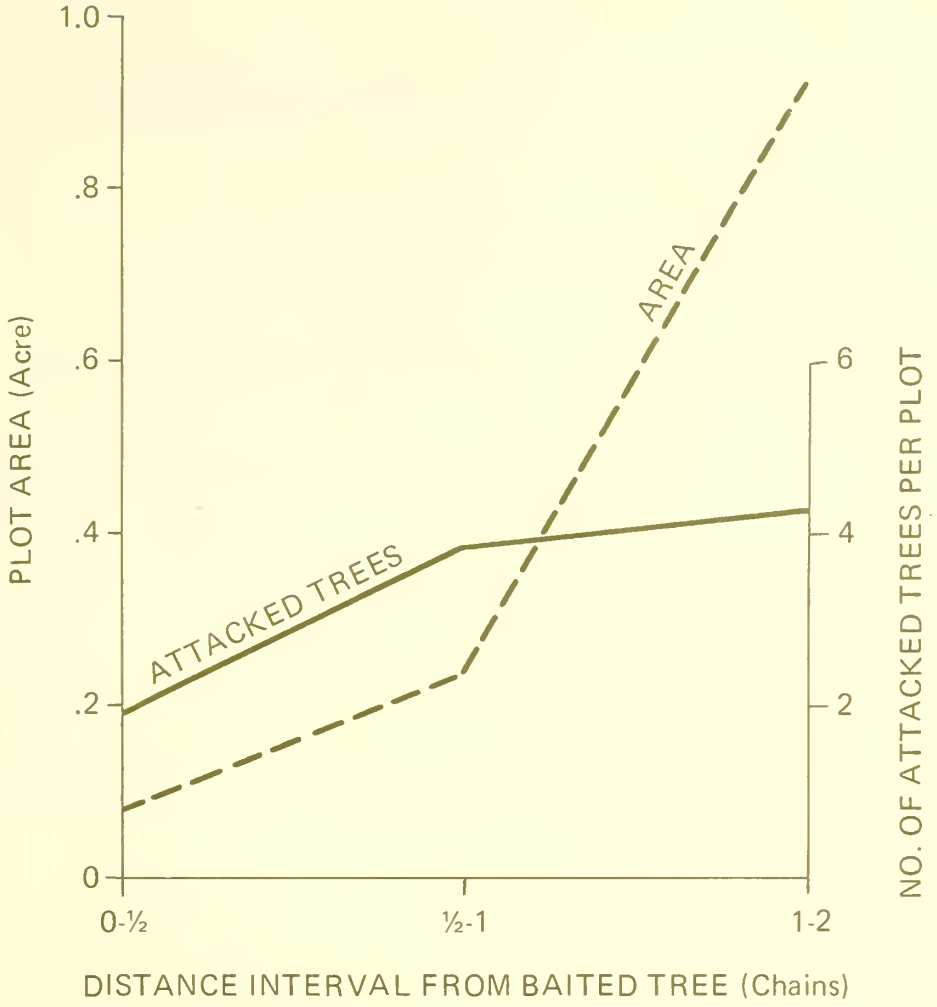

Figure 3.--Relationship of number of attacked Douglas-firs and plot area by distance from baited tree.

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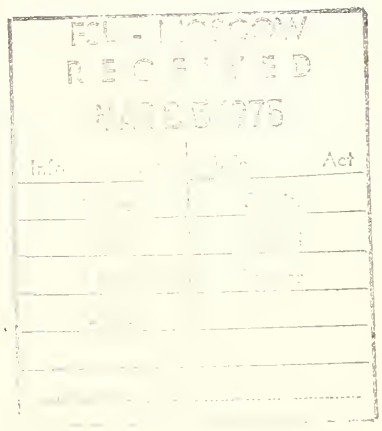
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